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20. Ultrasonic scanning inspection data has been exchanged among an AUSS-V unit at McDonnell Aircraft, a DuPont CalData system at the North Island NADEP and a Sigma system at the Cherry Point NADEP. The exchange of ultrasonic data for these three incompatible equipments has been accomplished using a neutral format medium compatible with the Standard for the Exchange of Product Model Data (STEP), the exchange specification now under development as the international specification for the exchange of all manufacturing and life cycle data. A commercial product for the exchange of digital nondestructive test data is planned.

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EXECUTIVE SUMMARY

The objective of this Small Business Innovation Research (SBIR) program was to develop methods/procedures to exchange digital ultrasonic inspection data generated on different, normally incompatible scanning systems. A recognized format to exchange ultrasonic inspection data among maintenance facilities, the manufacturers and central engineering facilities will lead to improvements in accept/reject/repair decisions. Exchanges between three different ultrasonic systems were demonstrated during this program, an Automated Ultrasonic Scanning System (AUSS-V) at McDonnell Aircraft Co. in St. Louis (a manufacturer of U.S.Navy aircraft) and two Naval Aviation Depot (NADEP) systems used for aircraft maintenance. The two NADEP systems were a Du Pont CalData Multisonic PC and Data Acquisition and Imaging system at North Island in San Diego and a Sigma Model UT2000 ultrasonic squirter system at Cherry Point. The data exchanges were accomplished with a data file format developed in this program and now under ballot in ASTM as, "Standard Guide for Data Fields for Computerized Transfer of Digital Ultrasonic Testing Data". The exchange specification used for the data transfer is based on the Product Data Exchange using STEP (Standard for Exchange of Product Model Data) (PDES/STEP). This acronym, PDES/STEP, refers to the exchange development activity in the U.S. in support of the international effort to make STEP an international standard through ISO. This exchange specification provides a neutral format specification intended to include manufacturing and life cycle data. Thus, the ultrasonic data exchanges have been accomplished through an exchange specification compatible with one planned for international data exchange and in conjunction with a proposed ASTM standard data field document. The software developed in this program to accomplish the exchange, the Logical Intermediate File Interface (LIFI), will form the basis for a new commercial product to expedite ultrasonic (and other digital nondestructive test) data exchange. Additional government-sponsored work is suggested to implement completely these ultrasonic data exchange methods. Additional ultrasonic inspection equipment at the NADEP facilities should be included in the exchange process. In addition, work is needed to obtain formal acceptance of the NDT data exchange concepts in STEP, so that these procedures become part of the international standard.

FOREWORD

This document reports the results of a 2-year, Phase II Small Business Innovation Research (SBIR) program directed toward the development of methods to transfer digital ultrasonic inspection data so that the data can be available to different, normally incompatible ultrasonic inspection systems. The work was funded under Naval Air Systems Command Contract No. N00019-89-C-0275. The data transfer demonstration was accomplished with newly developed software through a neutral format specification compatible with one being developed as an international standard for the exchange of manufacturing and life cycle data, a logical selection for the exchange of nondestructive test data.

ACKNOWLEDGEMENTS

The staff at Industrial Quality, Inc. is pleased to acknowledge significant contributors to this program from three subcontractors. Daniel King, Michael Emanuel, John Headrick and colleagues at McDonnell Aircraft in St. Louis wrote the translator software for the McDonnell Douglas AUSS units and provided important contributions to the general translator software development. David White, Du Pont CalData Systems, developed the translator software for the North Island NADEP CalData system. Timothy Harrington, Failure Analysis Associates, provided the translator software for the Sigma systems at Cherry Point. The program benefitted from technical discussion with colleagues at the National Institute of Standards and Technology, particularly John Rumble and Kent Reed. In addition, many Navy people took strong interest in the program. At the risk of missing a few of these, we cite, in particular, Robert Mathers at North Island, Richard Wood at Cherry Point, Tim Reich and Kenneth Steiert at Norfolk and Gwynn McConnell, NADC-Warminster and NAVAIR Headquarters personnel, J.E. (Steve) Stephenson, James Muller and Lewis Sloter.

TABLE OF CONTENTS

INTRODUCTION

Ultrasonic inspection of aircraft components is an important element in quality control in both the manufacturing and maintenance environments. Large immersion ultrasonic scanning systems have been in common use for many years. The increasing use of bonded structure, composites, honeycomb, etc., and the relatively recent availability and use of computer based data storage/retrieval systems are drastically changing and diversifying the appearance of ultrasonic test equipment and the interpretation of ultrasonic test results.

The aerospace industry has acquired more and more sophisticated automated ultrasonic scanning systems which utilize computerized motion control, data acquisition, and data analysis. Each manufacturer or military or civilian overhaul base has independently improved its capabilities for more versatile and comprehensive ultrasonic testing. Among the wide variety of systems being used, built and purchased there is also a wide variety of instrumentation, transducers, host computers and data acquisition techniques.

Any one ultrasonic system may do a superb job for a given location. However, there is little, or more often, no common ground between different testing systems. In a few cases, prime defense contractors will mandate that their sub-contractors use equipment compatible with their own. Between the primes, and, more important, between primes and end users such as overhaul bases, no standardized format for inspection data exists.

The goal of this program was to develop methods to permit exchange/transfer of inspection data among different brand/model ultrasonic scanning systems. The capability to exchange data from automated ultrasonic inspection systems is important as decisions must be made about acceptance or rejection of components in a maintenance environment. A recognized format to exchange ultrasonic inspection data among the maintenance facilities, the manufacturers and central engineering facilities will speed up such decisions and improve the quality of those decisions.

Ultrasonic Scanning Systems

Ultrasonic inspection has been used for many years in the aerospace industry. The need for lightweight, strong structures, the resulting limited capability for overdesign and the increasing use of bonded structures have all supported the requirements for reliable ultrasonic techniques as a strong element in inspection approaches. These ultrasonic techniques include a variety of hand-scan inspection

methods and mechanical scanning systems for both through-transmission and pulse-echo inspections. The older scanning systems provided very useful data, but one had to preselect a threshold level for the data collection and display. If one wanted to inspect a given part at several threshold levels, several scans had to be made.

The newer generation of automated ultrasonic scanning systems is tied to the increasing capability to use computers [1]. Inspection data can now be collected on a digital basis so that the part need be scanned only once. The threshold levels to aid in displaying images in order to make decisions for acceptance/repair/rejection can be selected by the operator or automatically in the computerized system. The data from a single scan can be presented for display and analysis at several digital levels. This represents a significant advance in ultrasonic inspection capability. The advance comes at a time when it is needed because of our increasing use of bonded and composite structure in the aerospace industry and the resultant requirement for cost-effective, reliable inspection to assure quality.

Automated ultrasonic scanning systems have evolved over the past decade. Developments have been made by several instrument/equipment manufacturers. In addition, the aerospace manufacturers themselves have pursued the development of automated ultrasonic scanners because of their belief that the equipment manufacturers were not meeting the need. Developments have come from the aerospace manufacturers such as Boeing, Martin Marietta, General Dynamics and McDonnell Douglas; the latter company entered the commercial inspection market with their in-house developed equipment, the Automated Ultrasonic Scanning System (AUSS). The ultrasonic systems include immersion types, bridge-gantry and robotic mounted squirter systems, arrays of transducers and recently, laser scanning systems to generate and detect ultrasound. Many of these modern systems collect in one scan the inspection data for through-transmission and pulse-echo from both sides.

THE ULTRASONIC DATA

Important elements in the ultrasonic data include the header information, the ultrasonic signal digitization approach and the methods for storing positional information and displaying the data. The header information will typically include data such as shown in Table 1.

The ultrasonic signal digitization usually involves the ultrasonic amplitude. However, in some systems such as the McDonnell Douglas AUSS pulse-echo system, the digitization involves the transit time (or depth within the sample) of the pulse-echo signal. Many of these systems can record ultrasonic signals over a range of more than 100 dB without any operator intervention or adjustment of external gain.

It is important to appreciate that the absolute value of the ultrasonic signal amplitude (as normally used in through-transmission) must be related to a standard before one can make realistic decisions about the disposition of a part. Obviously, some parts are more attenuating than others so the absolute value of ultrasonic amplitude must be examined in its relationship to signal amplitudes received from a comparable inspection of a standard component. Variables in signal amplitude relate to items such as the pulser, the ultrasonic transducer, the surface roughness and orientation, and the attenuation within the component, as examples. Another significant amplitude-level variable concerns parts that are inspected with the instrument gain being controlled as a function of position on the test object. This is becoming common, for example, with trailing edge components whose thickness decreases dramatically as one nears the edge.

How the position information for the ultrasonic scan is obtained and recorded is another significant variable when one compares these automated systems. There is now increasing interest in and demand for contour-following capability for scans of complex curvature parts. Nevertheless, the images displayed are flat projections of the data.

TABLE 1 . Outline of Information Needed for Reporting Ultrasonic Test Results

1. Header Information
2. Inspection System Description
3. Pulser Description
4. Receiver Description
5. Gate Description
6. Search Unit Description
7. Test Sample Description
8. Coordinate System and Scan Description
9. Test Parameters
10. Test Results

DATA EXCHANGE APPROACH

There has been a strong effort in electronic data transfer, largely supported by the Department of Defense (DOD) Computer Aided Acquisition and Logistical Support projects (CALS) [2,3]. Another major effort in data exchange concerns the transfer of CAD/CAM data through a neutral format specification. The consensus specification now being used for the exchange of CAD/CAM data is the Initial Graphics Exchange Specification, IGES. This system requires a translator to move the data from a given (probably proprietary) system to and from a neutral file format. The intermediate approach offers several advantages over a direct transfer between two or more systems. These include: 1. easy entry into the system by new manufacturers or models - only two translators will be needed, 2. protection of proprietary information (since actual exchange will be through an intermediate system) and 3. in the case of the specification in use for CAD/CAM and related data, compatibility with standards used or planned by ANSI, ISO and MIL standards. Figure 1 demonstrates the principle of this exchange approach. Translators or processors permit data to be moved to and from a proprietary data handling system and the neutral intermediate exchange.

The IGES specification has evolved over the last decade [4,5]. IGES, now an ANSI standard, allows exchange of information among computer-aided design systems [6]. It defines file structure format, a language format, and the representation of geometric, topical and non-geometrical product definition data in these formats to describe and communicate engineering characteristics of physical objects as manufactured products. It allows incompatible CAD systems from different vendors to translate data through a neutral format using pre- and post-processors. An important feature of the intermediate exchange approach is that proprietary interests of equipment manufacturers are protected since only the design of the processor to their equipment requires detailed knowledge of proprietary data handling approaches.

Under development and intended to take over many of the functions of IGES is the Standard for the Exchange of Product Model Data (STEP). This is being developed as an international standard whose goal is to develop a neutral mechanism to completely represent product data throughout its life cycle. PDES (Product Data Exchange using STEP) is the development activity in the United States in support of STEP. In 1990 the acronym was altered from Product Data Exchange Specification (PDES) [7] to its current one. This was done to clarify its intent of supporting the development and implementation of STEP in the U.S. The goals of the PDES organization are to ensure that the requirements of

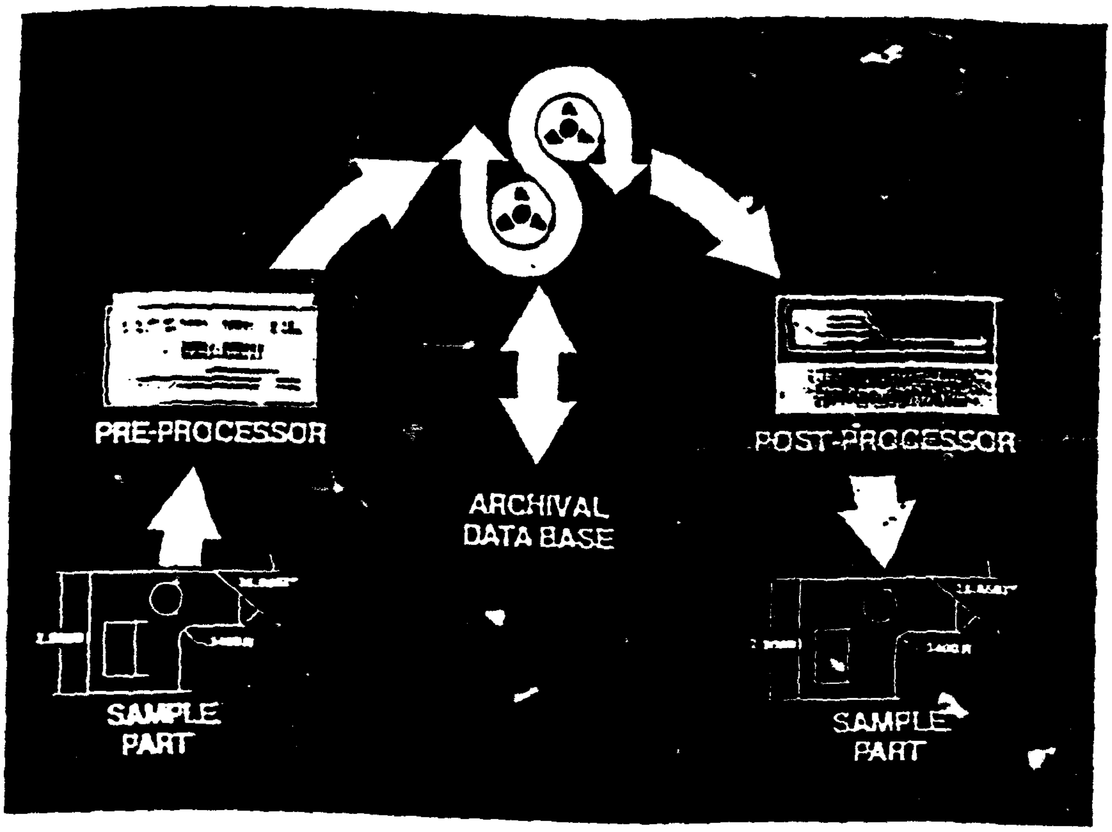


FIG. 1 Illustration of the intermediate exchange approach

U.S. industry are incorporated into the standard and to provide a methodology for U.S. industry to implement STEP standards.

Although there are many concepts and procedures for the exchange of digital data [8], the approaches considered for the exchange of ultrasonic inspection data quickly concentrated on the IGES/PDES/STEP type of intermediate exchange. The strong activity to bring PDES/STEP into use internationally, the planned use of this neutral format specification for all manufacturing and life cycle data, and the availability to the program of people familiar with PDES/STEP and its development all contributed to the selection of PDES/STEP as the basis for exchange of digital ultrasonic data.

ULTRASONIC DATA FIELDS

The type of information that should be available in order to understand a transferred ultrasonic data file was listed in Table 1. We have expanded on that listing and put together a formal data field guide suitable for transfer of an ultrasonic file. The complete guide, in the form of an ASTM standard and as now in ballot in ASTM, is given in Appendix A.

This data field listing was developed over the entire 2-year project, starting with a Workshop on the Exchange of Digital Ultrasonic Data, held early in the program (November 7 and 8, 1989). The Workshop brought together the NAVAIR program personnel, key people from the Naval Aviation Depots and other Navy facilities, specialists from the National Institute of Standards and Technology (NIST) and the contract team. In addition to detailed discussions about the data fields needed to describe a digital ultrasonic inspection file, the Workshop also focussed attention on the potential exchange specifications. Appendix B includes the program report summarizing the Workshop.

Material as listed in the data field guide (Appendix A) is necessary as a first step. Data fields as described there have been used to proceed with the translator software. An early step was to prepare the data field guide in computer language. This was done in EXPRESS, the language used for PDES/STEP. Table 2 shows this part of the translator software development process.

The file format and contents for the intermediate data file standard have been established. This file is organized into three parts, the PDES File Header, a Data Area and the Intermediate File Header. The PDES File Header is not accessible to users: it provides the communication link between the data and the PDES intermediate exchange system. The Data Area contains blocks that describe the inspection method, equipment and data. In addition, an intermediate data file translator is needed. This vendor-designed software allows access into and out of the intermediate file format. It consists of an interface, a controlling module, vendor proprietary file services, and intermediate file services.

A software package has been developed to assist entry into the system by new manufacturers or models. This software package insures communication with the intermediate file format. This software consists of the Logical Intermediate File Interface (LIFI) and the Intermediate File services. The proprietary LIFI is a set of functions that provides a logical systematic method of getting data into and out of the intermediate data file. It consists of a set of modules that perform

TABLE 2. EXPRESS Descriptions of Ultrasonic Data File

```
(*
This document defines EXPRESS entities for the various groups and
sub-groups in the Intermediate File Format Contents documentation.

HEADER


*)

SCHEMA INTERMEDIATE_FILE;

TYPE focal_length = ENUMERATION OF
     (NONE,
      FLAT,
      LONG,
      MEDIUM,
      SHORT);
END_TYPE;
(*


*)
ENTITY TARGET_PT;
    des                                       : STRING(80);
    x_coord                                   : INTEGER;
    y_coord                                   : INTEGER;
END_ENTITY;
(*


*)
ENTITY HEADER_INTERMEDIATE;
    format_rev_code                           : STRING(10);
    format_rev_date                           : STRING(10);
    testing_co                                : STRING(80);
    int_file_name                             : STRING(80);
    src_file_name                             : STRING(80);
    file_descr_notes                          : STRING(200);
    test_date                                 : STRING(10);
    test_time                                 : STRING(10);
    type_of_test                              : STRING(80);
    other_tests                               : STRING(80);
    operator_name                             : STRING(80);
    operator_id                               : STRING(80);
    inspection_spec                           : STRING(80);
    date_of_standard                          : STRING(10);
    accept_criteria                           : STRING(80);
    notes                                     : STRING(200);
    num_segments                              : INTEGER;
    segments                                  : ARRAY [1:#] of SEGMENT;
END_ENTITY;
(*


*)
ENTITY PULSAR_DESCR;
    pul_sys_manufacturer                      : STRING(80);
    pul_sys_model_num                         : STRING(40);
    pul_type                                  : STRING(80);
    pul_height                                : REAL;
```

```
    pul_width                              : REAL;
    pul_last_cal_date                      : STRING(10);
    pul_notes                              : STRING(200);
END_ENTITY;
(*


*)
ENTITY REC_DESCR;
    rec_manufacturer                       : STRING(80);
    rec_model_num                          : STRING(80);
    rec_resp_center_freq                   : REAL;
    rec_fixed_gain                         : REAL;
    rec_user_gain                          : REAL;
    rec_last_cal_date                      : STRING(10);
    rec_notes                              : STRING(200);
END_ENTITY;
(*


*)
ENTITY GATE_TYPE;
    gate_type                              : STRING(80);
    gate_synch                             : STRING(80);
    gate_start_delay                       : STRING(80);
    gate_width                             : STRING(80);
    gate_treshold                          : STRING(80);
    gate_notes                             : STRING(200);
END_ENTITY;
(*


*)
ENTITY GATE_DESCR;
    num_gates                              : INTEGER;
    gates                                  : ARRAY [1:#] of GATE_TYPE;
END_ENTITY;
(*


*)
ENTITY TRANS_DESCR;
    trans_manufacturer                     : STRING(80);
    trans_model                            : STRING(80);
    trans_serial_num                       : STRING(80);
    trans_element_diam                     : REAL;
    trans_beam_diam                        : REAL;
    trans_meas_loc                         : STRING(80);
    trans_focal_length                     : focal_length;
    trans_center_freq                      : REAL;
    trans_bandwidth                        : REAL;
    trans_dig_num                          : INTEGER;
    trans_waveform                         : ARRAY [1:#] of INTEGER;
    trans_notes                            : STRING(200);
    trans_coupling_medium                  : STRING(80);
    rec_manufacturer                       : STRING(80);
    rec_model                              : STRING(80);
    rec_serial_num                         : STRING(80);
    rec_element_diam                       : REAL;
    rec_beam_diam                          : REAL;
```

```
      rec_meas_loc                              : STRING(80);
      rec_focal_length                          : focal_length;
      rec_center_freq                           : REAL;
      rec_bandwidth                             : REAL;
      rec_dig_num                               : INTEGER;
      rec_waveform                              : ARRAY [1:#] of INTEGER;
      rec_notes                                 : STRING(200);
      rec_coupling_medium                       : STRING(80);
  END_ENTITY;
  (*

  *)
  ENTITY INSP_SYS_DESCR;
      system_manufacturer                       : STRING(80);
      model                                     : STRING(80);
      serial_number                             : STRING(80);
      pulsar_descr                              : EXTERNAL PULSAR_DESCR;
      receiver_descr                            : EXTERNAL REC_DESCR;
      gate_des                                  : EXTERNAL GATE_DESCR;
      trans_des                                 : EXTERNAL TRANS_DESCR;
  END_ENTITY;
  (*

  *)
  ENTITY TEST_SAMPLE;
      sample_id                                 : STRING(80);
      sample_name                               : STRING(80);
      sample_des                                : STRING(80);
      sample_material                           : STRING(80);
      sample_notes                              : STRING(200);
      ref_stand_id                              : STRING(80);
      ref_stand_des                             : STRING(80);
      ref_stand_file_name                       : STRING(80);
      ref_stand_file_loc                        : STRING(80);
  END_ENTITY;
  (*

  *)
  ENTITY MACH_COORD;
      scan_axis                                 : STRING(80);
      index_axis                                : STRING(80);
      third_axis                                : STRING(80);
      mach_coord_ref                            : STRING(80);
  END_ENTITY;
  (*

  *)
  ENTITY PART_COORD;
      x_axis                                    : STRING(80);
      y_axis                                    : STRING(80);
      z_axis                                    : STRING(80);
      part_coord_ref                            : STRING(80);
  END_ENTITY;
  (*

  *)
  ENTITY OBJECT_TAR_POINTS;
      num_tar_pts                               : INTEGER;
      tar_pts                                   : ARRAY [1:#] of TARGET_PT;
```

```
END_ENTITY;
(*

*)
ENTITY DATA_PLANE;
    des                              : STRING(80);
    coord_sys_notes                  : STRING(200);
END_ENTITY;
(*


*)
ENTITY SCAN_LINE;
    data                             : ARRAY [1:#] of INTEGER;
END_ENTITY;
(*


*)
ENTITY TEST_RESULTS;
    test_type                        : STRING(80);
    test_data_min                    : INTEGER;
    test_data_max                    : INTEGER;
    eng_units_min                    : REAL;
    eng_units_max                    : REAL;
    num_bits                         : INTEGER;
    type_data_scale                  : STRING(40);
    data_step_size                   : REAL;
    data_format                      : STRING(80);
    num_colors                       : INTEGER;
    dist_colors                      : STRING(80);
    dist_samp_pts                    : REAL;
    dist_index_pts                   : REAL;
    notes_intervals                  : STRING(200);
    data_pts_num                     : INTEGER;
    line_data                        : ARRAY [1:#] of SCAN_LINE;
END_ENTITY;
(*


*)
ENTITY TEST_PARAMETERS;
    Num_data_pts_per_coord           : INTEGER;
    tests_res                        : ARRAY [1:#] of TEST_RESULTS;
END_ENTITY;
(*


*)
ENTITY SEGMENT;
    scan_seg_num                     : INTEGER;
    scan_seg_des                     : STRING(80);
    scan_seg_loc                     : STRING(80);
    scan_seg_orient                  : STRING(80);
    scan_pattern_des                 : STRING(80);
    annotation                       : STRING(80);
    inspection_sys_des               : EXTERNAL INSP_SYS_DESCR;
    test_samp                        : EXTERNAL TEST_SAMPLE;
    machine_coord                    : EXTERNAL MACH_COORD;
    target_points                    : EXTERNAL OBJECT_TAR_POINTS;
    data_plane                       : EXTERNAL DATA_PLANE;
    test_data                        : EXTERNAL TEST_PARAMETERS;
END_ENTITY;
```

the following functions: 1. Read and write information into the intermediate file, 2. Error reporting and logging, and 3. Supplementary and configuration functions. Additional modules provide a custom programming interface for a file regardless of its physical file format and a PDES specific I/O module. The Intermediate File services provide all I/O and low-level formatting to the PDES format intermediate data file. The vendor designed translator is software that is vendor specific. It is designed to use the Logical Intermediate File Interface to read and write to an intermediate data file. The vendor proprietary data base services is a software package that vendors should have for reading and writing their proprietary ultrasonic data file format. The flow of information to and from the intermediate exchange specification and the vendor ultrasonic data is illustrated in Fiqure 2.

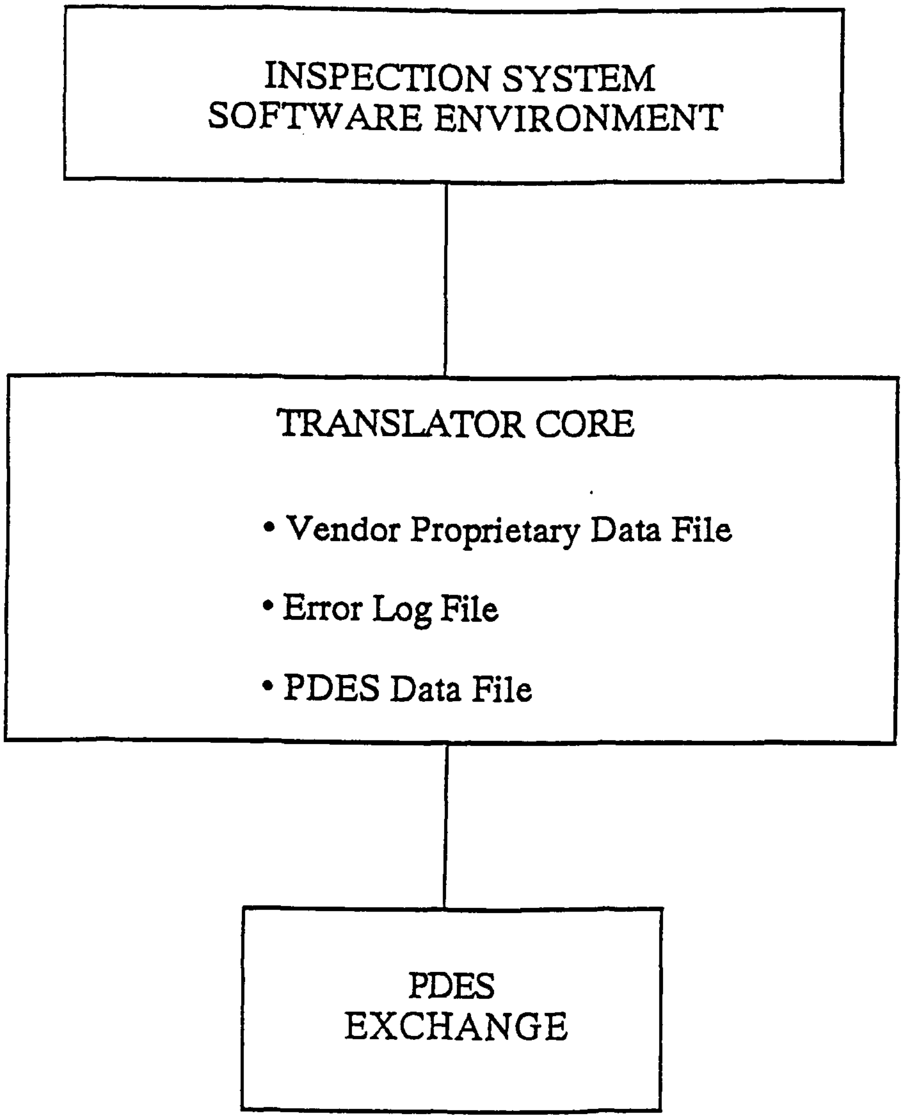


FIGURE 2. Flow of information for the exchange

EXPERIMENTAL RESULTS

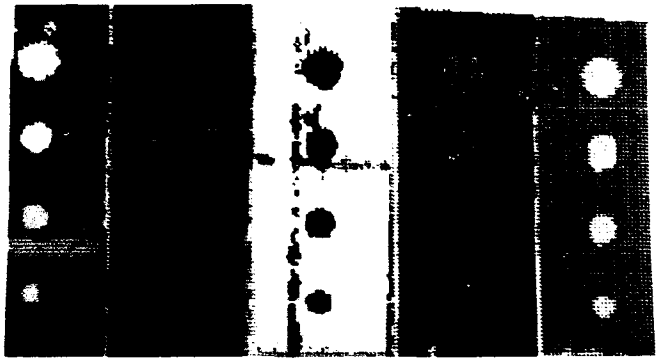
The primary experimental result is the demonstration of digital ultrasonic data exchange involving the three facilities described earlier, MCAIR, and the NADEPS at North Island and Cherry Point. The data shown here include ultrasonic inspection files generated on all three demonstration systems and reproduced at MCAIR, CalData and IQI. It was never intended to reproduce inspection files in the Sigma system (because of its limited outdated capability), but instead on a PC or workstation. The IQI file reproductions were accomplished on a 486 PC system. These illustrations were made from black and white photographs of color data print-outs (MCAIR and CalData) with different colors representing different digital values; therefore, the grey scales on the photographs and this reproduction do not completely match. Nevertheless, the figures presented demonstrate effective data exchanges between all the systems. The intermediate file data exchanges are by means of computer disks. Additional information exchanged includes color paper print-outs and Polaroid photographs. The largest intermediate file transferred is 3 MBytes.

Figure 3 shows several reproductions of a MCAIR ultrasonic scan of a graphite-epoxy step wedge. This ultrasonic data file actually consisted of three segments, showing the through-transmission results (as shown in Fig. 3) and pulse-echo results from each side of the wedge. The complete file size was about 300 KBytes. Top view is a reproduction of a CalData color print-out (following translation of the intermediate file into a CalData file). The middle view is a reproduction of the MCAIR color print-out. The bottom view is the IQI image as photographed from the IQI PC monitor. All the reproductions are multi-generation copies and include the differences caused by the color selections from the paper print-outs. The Caldata and IQI file reproductions were accomplished through the neutral intermediate specification.

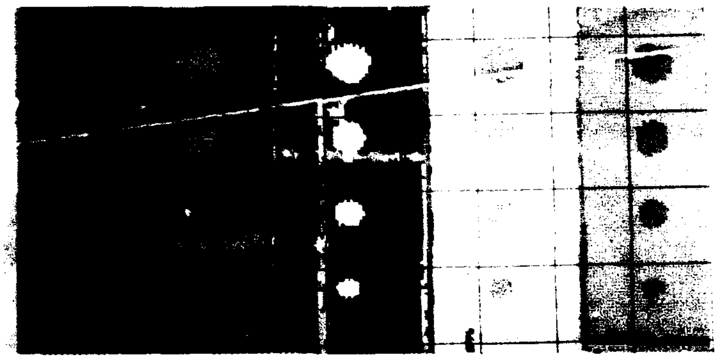
Figure 4 shows similar results for an AV-8 composite panel. The original ultrasonic data was obtained on a Sigma system at Failure Analysis Associates, a system identical to the unit at Cherry Point. The file size was about 550 KBytes. Transferred and reproduced file images are given in the same order as Figure 3, CalData (top, reproduced from color print-out), MCAIR, center and IQI, bottom photo.

Figure 5 shows similar results for a North Island ultrasonic scan, again presented in the same order as the previous two illustrations. This file of an F-18 outer wing skin is a large one (3 MBytes). The IQI PC display can show the entire image and can also permit the operator to roam around in the image to display portions of the ultrasonic data with improved spatial resolution.

A. CalData



B. MCAIR



C. IQI

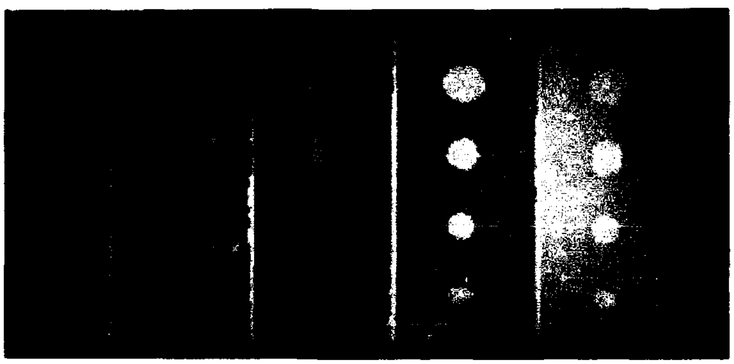


FIGURE 3. Reproductions of ultrasonic data files transferred through the intermediate specification. File showing ultrasonic scan of Graphite-Epoxy step wedge was prepared on an AUSS at MCAIR. Scans show steps and holes and some artifacs, such as U-shaped indication at top of second step from the left (probably a delamination generated from extensive use of the sample).

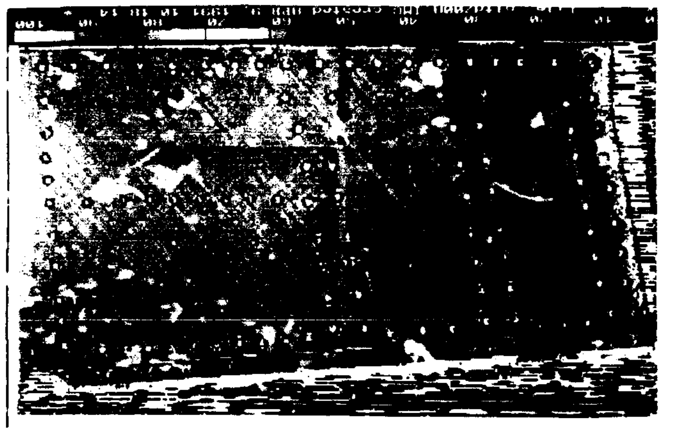
A. CalData

B. MCAIR

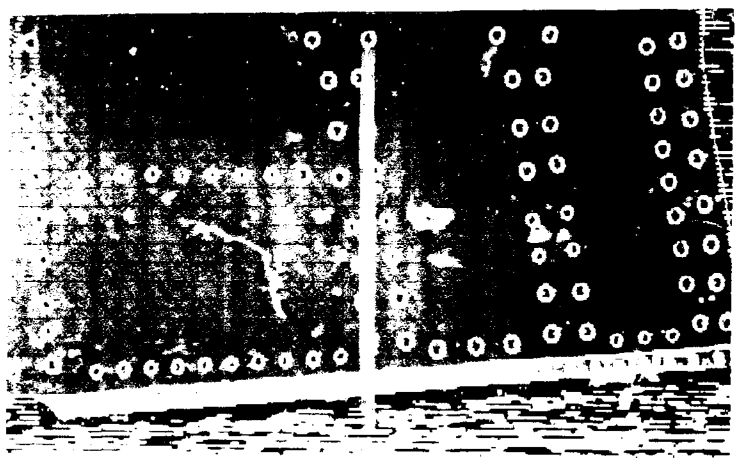
C. IQI

FIGURE 4. Ultrasonic images similar to those of Fig. 3, except priginal scan was taken with a Sigma system

A. CalData



B. MCAIR



C. IQI

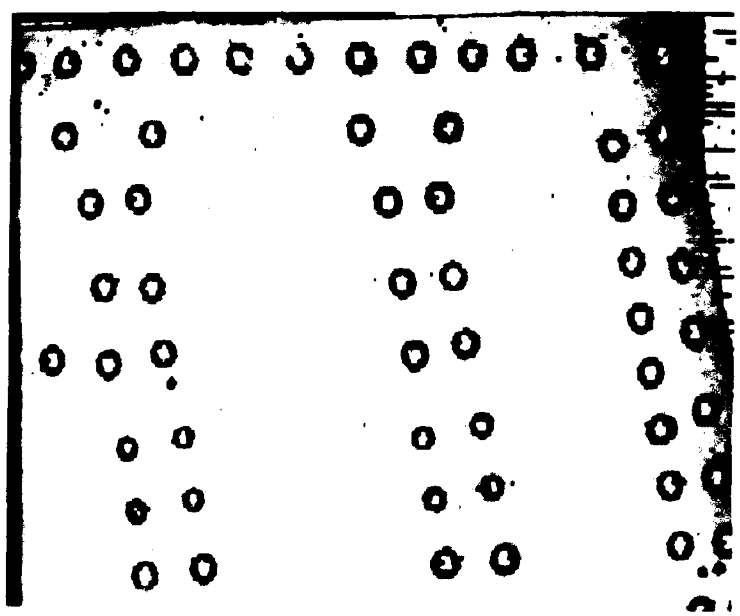


FIGURE 5. Similar ultrasonic images. The original scan was done at North Island using a CalData system. The IQI image sows only the upper right portion of this large file as explained in the text.

These results demonstrate the capability to exchange ultrasonic inspection data generated on different ultrasonic scanning systems. Some of the exchange files are reproduced as color print-outs. Color is the standard display for the CalData system. Both color and black and white displays/print-outs are available at MCAIR, CalData and IQI. The color palettes for the various color images are different for each system, a fact that makes color comparisons difficult. Nevertheless, it must be emphasized that each of the exchange organizations displays the ultrasonic data in their native format, a format that is understandable to them.

All the ultrasonic data exchange results shown in this report were shown to Navy/Government attendees at a demonstraton meeting held at IQI on June 5, 1991. A report on that meeting is given in Appendix C.

CONCLUSIONS

Methods have been developed to permit the exchange of data among different ultrasonic inspection scanning systems. The ultrasonic data file format that has been used in the demonstrated exchanges is one that is presently under discussion in ASTM. It is our belief that this digital ultrasonic data field description, shown in Appendix A, will in some form eventually become an ASTM standard. The exchange specification used for the data transfer is a neutral format, compatible with the Standard for the Exchange of Product Model Data (STEP), the specification now in intense development to be the international standard for the exchange of all manufacturing and life cycle data.

These points are made to emphasize that the demonstrated procedures to exchange ultrasonic inspection scanning data have been accomplished using documents that will, in some form, become standards accepted for such data exchanges. That was the objective of this program, namely to develop procedures for the exchange of ultrasonic data that would make use of "accepted" methods as much as possible. An additional point that should be made is that STEP, intended as the exchange specification for all manufacturing and life cycle data, is a logical medium for the exchange of nondestructive testing data.

The methods for the data exchanges make use of "accepted", public domain procedures as indicated. In addition, there are proprietary aspects to the developed software. The connections to the proprietary instrumentation make use of economically sensitive information. In addition, the connecting link between the proprietary instrumentation and STEP, the Logical Intermediate File Interface, is software proprietary to Industrial Quality, Inc. This software will form the basis for a commercial product, one that will make LIFI available to ultrasonic instrument manufacturers and users and/or as part of an ultrasonic inspection analysis workstation. The software developed in this program is compatible with personal computer instrumentation. This nondestructive testing workstation need not be limited to ultrasonic inspection data. Any digital data can be included and a start in this direction for radiographic and radioscopic data is already under way.

We are proceeding to publicize this development in the technical community. As this final report is prepared, presentations on the ultrasonic data exchange program are planned for the American Society for Nondestructive Testing Fall Conference in Boston in September, 1991 [9,10] and at the DOD NDT Conference in Annapolis, November, 1991 [11].

Finally, it is appropriate to discuss the SBIR Phase III activities that should follow this program. On the matter of

commercialization, IQI has copyrighted the LJFI software and has entered discussions with manufacturers of ultrasonic scanning systems. There is also a logical government-sponsored Phase III activity to obtain full standardization approval of the exchange methods used in this program. The data file guide, although not yet formally approved, is proceeding in ASTM; this document will, in some form, become an ASTM standard. The major government Phase III project should be directed toward incorporating in a formal way the ultrasonic (and other nondestructive testing) data exchange concepts in STEP so that these approaches are accepted internationally. That is beyond the resources of a small business such as IQI. Therefore, we suggest a government-funded project to incorporate the NDT data exchange methods in STEP. An additional short-term government-sponsored Phase III activity is to assure that ultrasonic scanning equipment used at each NADEP can participate in ultrasonic data exchange. In the near-term, this translator development activity appears to involve the SAIC Ultra-Image equipment, since this inspection unit is used at all the NADEP facilities. This short-term project would make it possible for new government procurement orders to specify that manufacturers of naval aircraft components assure that their ultrasonic inspection systems are capable of data exchange with ultrasonic inspection systems at NADEP facilities.

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10. Jones, T.S., Gaynor, E.S., Berger, H. and Emanuel, M.J., "Development of an Ultrasonic Translation and Viewing Workstation", ibid, 1991.

11. Jones, T.S., Gaynor, E.S., Berger. H. and Emanuel, M.J., "Data Exchange Methods for Digital Ultrasonic Systems", Abstract for the DOD NDT Conference, Annapolis, MD, Nov. 4-7. 1991.

APPENDIX A

STANDARD GUIDE FOR DATA FIELDS
FOR COMPUTERIZED TRANSFER
OF DIGITAL ULTRASONIC TESTING DATA,
DOCUMENT IN BALLOT AT ASTM COMMITTEE E-7

STANDARD GUIDE FOR DATA FIELDS FOR COMPUTERIZED TRANSFER OF DIGITAL ULTRASONIC TESTING DATA

1. Scope:

1.1 This guide provides a listing and description of the fields that are recommended for inclusion in a digital ultrasonic examination data base to facilitate the transfer of such data. The guide is prepared for use particularly with digital image data obtained from ultrasonic scanning systems. The field listing includes those fields regarded as necessary for inclusion in the data base (as indicated by an asterisk); these fields, so marked, are regarded as the minimum information necessary for a transfer recipient to understand the data. In addition, other optional fields are listed as a reminder of the types of information that may be useful for additional understanding of the data, or applicable to a limited number of applications.

1.2 It is recognized that organizations may have in place an internal format for the storage and retrieval of ultrasonic examination data. This guide should not impede the use of such formats since it is probable that the necessary fields are already included in such internal data bases, or that the few additions can be made. The numerical listing indicated in this guide is only for convenience; the specific numbers carry no inherent significance and are not a part of the data file.

1.3 The types of ultrasonic examination systems that appear useful in relation to this guide include those described in E 114, E 214 and E 1001. Many of the terms used are defined in E 1013 and E 1316. The search unit parameters used in this guide follow from those used in E 1065.

1.4 It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Referenced Documents:

2.1 ASTM Standards

- E 114 Standard Practice for Ultrasonic Pulse-Echo Straight - Beam Testing by the Contact Method
- E 214 Standard Practice for Immersed Ultrasonic Examination by the Reflection Method Using Pulsed Longitudinal Waves
- E 1001 Standard Practice for Detection and Evaluation of Discontinuities by the Immersed Pulse-Echo Ultrasonic Method Using Longitudinal Waves.
- E 1013 Terminology of Computerized Systems

E 1065 Standard Guide for Evaluating Characteristics of Ultrasonic Search Units

E 1316 Terminology Relating to Nondestructive Testing

3. Significance And Use:

3.1 The primary use of this standard is to provide a standardized approach for the data file to be used for the transfer of digital ultrasonic data from one user to another where the two users are working with dissimilar ultrasonic systems. This standard describes the contents, both required and optional for an intermediate data file which can be created from the native format of the ultrasonic system on which the data was collected and which can be converted into the native format of the receiving ultrasonic or data analysis system. The development of translator software to accomplish these data format conversions is being addressed under a separate effort; this will include specific items needed for the data transfer, for example, language used, memory requirements and intermediate specification, including detailed data formats and structures. The guide will also be useful in the archival storage and retrieval of ultrasonic data as either a data format specifier or as a guide to the data elements which should be included in the archival file.

3.2 Although the recommended field listing includes more than 120 items, only about a third of those are regarded as essential and marked with an asterisk. Fields so marked must be addressed in the data base. The other fields recommended provide additional information that a user will find helpful in understanding the ultrasonic examination result. These header field items will, in most cases, make up only a very small part of an ultrasonic examination file. The actual stream of ultrasonic data that make up the image will take up the largest part of the data base. Since an ultrasonic image file will normally be large, the concept of data compression will be considered in many cases. Compressed data should be noted, along with a description of the compression method, as indicated in Field No. 122.

3.3 This guide provides a data file for all of the ultrasonic information collected in a single scan. Some systems record multiple inspection results during a single scan. For example, through transmission attenuation data as well as pulse echo thickness data may be recorded at the same time. These data may be stored in separate image planes; see Field 102. In other systems, complete digitized waveforms may be recorded at each inspeciton point. It is recognized that the complete examination record may contain several files, for example, for the same examination method in different object areas, with or without image processing, for different examination methods (through-transmission, pulse-echo, radiologic, infrared, etc.) collected during the same or during different scan sessions, and for variations within a single method (frequency change, etc.). Information about the existence of other images / examination records for the examined object should be noted in the appropriate fields. A single image plane may be

one created by overlaying or processing results for multiple examination approaches, for example data fusion. For such images, the notes sections must clearly state how the image for this file was created.

4. Description of the Field Listings.

4.1 Section 5 is a recommended field format for the computerized transfer of ultrasonic examination data. There are three columns of information, as indicated in 4.2, 4.3 and 4.4.

4.2 **Field Number:** A reference number for ease of use in dealing with the individual fields within this Standard Guide. This number has no permanent value and does not become part of the data base itself.

4.3 **Field Name and Description:** The complete name of the field, descriptive of the element of information that would be included in this field of the data base.

4.4 **Data Type / Units:** A listing of the types of information which would be included in the field and/or the units in which the values are expressed.

4.5 The information for reporting ultrasonic test results is divided into 10 segments, as follows:

- Header Information
- Examination System Description
- Pulser Description
- Receiver Description
- Gate Description
- Search Unit Description
- Examined Sample Description
- Coordinate System and Scan Description
- Examination Parameters
- Examination Results

4.6 Additional explanations and allowable entries for some fields are given in Section 6.

5. Field Listing

Field No.#		Field Name and Description	Data Type / Units##
Header Information			
1.	*	Intermediate file name	alphanumeric string**
2.	*	Format revision code	alphanumeric string
3.	*	Format revision date	yyyy/mm/dd**
4.	*	Source file name	alphanumeric string
5.		Examination file description notes	alphanumeric string
6.	*	Examining company and location	alphanumeric string**
7.	*	Examination date	yyyy/mm/dd
8.	*	Examination time	hh:mm:ss
9.	*	Type of examination	alphanumeric string**
10.		Other examinations performed	alphanumeric string**
11.		Operator Name	alphanumeric string
12.	*	Operator identification code	alphanumeric string
13.	*	ASTM, ISO or other applicable standard inspection specification	alphanumeric string
14.		Date of applicable standard	yyyy/mm/dd
15.	*	Acceptance criteria	alphanumeric string
16.	*	System of units	alphanumeric string**
17.		Notes	alphanumeric string
Examination System Description			
18.		Examination system manufacturer(s)	alphanumeric string**
19.	*	Examination system model	alphanumeric string
20.		Examination system serial number	alphanumeric string
Pulser Description			
21.		Pulser electronics manufacturer	alphanumeric string
22.		Pulser electronics model number	alphanumeric string
23.		Pulser type	alphanumeric string**
24.		Pulse repetition frequency	real number, kiloHertz
25.		Pulse height	alphanumeric string**
26.		Pulse width	real number, nsec
27.		Last calibration date	yyyy/mm/dd
28.		Notes on pulser section	alphanumeric string
Receiver Description			
29.		Receiver electronics manufacturer	alphanumeric string
30.		Receiver electronics model	alphanumeric string

Field numbers are for reference only. They do not imply a necessity to include all those fields in any specific database nor do they imply a requirement that fields be used in this particular order.

Units listed first are SI; secondary units are English (U.S. Customary); see Field #16.

* Denotes essential field for computerization of test results.

** See Section 6 for further explanation.

31.	Receiver electronics response center frequency	real number, MHz**
32.	Receiver bandwidth	real number, MHz**
33.	Fixed receiver gain	real number, dB
34.	User selected receiver gain	real number, dB
35.	Last calibration date	yyyy/mm/dd
36.	Notes on receiver section	alphanumeric string

Gate Description

37.	Number of gates	integer
38.	Gate type	alphanumeric string**
39.	Gate synchronization	alphanumeric string
40.	Gate start delay	alphanumeric string
41.	Gate width	alphanumeric string
42.	Gate threshold level	alphanumeric string
43.	Notes on gate section	alphanumeric string

Search Unit Description

44.	Transmit search unit manufacturer	alphanumeric string
45.	Transmit search unit model	alphanumeric string
46.	Transmit search unit serial number	alphanumeric string
47.	Transmit search unit element diameter	real number
48.	Measured beam diameter of the Transmit search unit at the examination surface	real number
49.	Location of measurement of beam diameter of the transmit search unit	alphanumeric string**
50.	Transmit search unit focal length	real number**
51.	Transmit search unit nominal frequency	real number, MHz
52.	Transmit search unit response center frequency	real number, MHz
53.	Transmit search unit response bandwidth	real number, MHz
54.	Transmit search unit cable type	alphanumeric string
55.	Transmit search unit cable length	real number
56.	Number of values for Transmit search unit digitized waveform	integer**
57.	Transmit search unit waveform values	real number
58.	Notes on Transmit search unit waveform	alphanumeric string
59.	Transmit search unit coupling technique and medium	alphanumeric string
60.	Receive search unit manufacturer	alphanumeric string
61.	Receive search unit model number	alphanumeric string
62.	Receive search unit serial number	alphanumeric string
63.	Receive search unit element diameter	real number
64.	Measured beam diameter of the Receive search unit at the examination surface	real number
65.	Location of measurement of beam diameter of the receive search unit	alphanumeric string**
66.	Receive search unit focal length	real number**
67.	Receive search unit nominal frequency	real number, MHz
68.	Receive search unit response center frequency	real number, MHz
69.	Receive search unit response bandwidth	real number, MHz
70.	Receive search unit cable type	alphanumeric string
71.	Receive search unit cable length	real number

72.		Number of values for Receive search unit digitized waveform	integer**
73.		Receive search unit waveform values	real number
74.		Notes on Receive search unit waveform	alphanumeric string
75.		Receive search unit coupling technique and medium	alphanumeric string

Examined Sample Description

76.	*	Examined sample identification	alphanumeric string
77.	*	Examined sample name	alphanumeric string
78.		Examined sample description	alphanumeric string
79.	*	Examined sample material	alphanumeric string
80.		Examined sample notes (history, use, etc.)	alphanumeric string**
81.	*	Number of scan segments for this part	integer
82.		Reference sample identification	alphanumeric string
83.		Reference sample description	alphanumeric string
84.		Reference sample file name/location	alphanumeric string
85.		Reference sample notes (use, etc.)	alphanumeric string**

Coordinate System and Scan Description

Machine Coordinate System

86.		Machine scan axis	alphanumeric string**
87.		Machine index axis	alphanumeric string
88.		Machine third axis	alphanumeric string
89.		Reference for machine coordinate system	alphanumeric string

Part Coordinate System

90.		First part axis	alphanumeric string**
91.		Second part axis	alphanumeric string
92.		Third part axis	alphanumeric string
93.		Reference for part coordinate system	alphanumeric string

Object Target Points

94.	*	Number of target points	integer
95.	*	Description of target point	alphanumeric string
96.	*	Coordinate of target point in first part axis	real number
97.	*	Coordinate of target point in second part axis	real number
98.		Coordinate of target point in third part axis	real number

Data Plane

99.		Description of the plane onto which data will be projected	alphanumeric string
100.		Coordinate system notes	alphanumeric string

Examination Parameters

101.	*	Coordinate location number	integer
102.	*	Number of data values per coordinate location	integer**
103.	*	Minimum value of test data range or resolution	integer**
104.	*	Maximum value of test data range or resolution	integer**

105.	*	Engineering units for minimum legal data value	alphanumeric string**
106.	*	Engineering units for maximum legal data value	alphanumeric string**
107.	*	Number of bits to which the original data was digitized.	integer
108.	*	Type of data scale	alphanumeric string**
109.	*	Size of data step	real number**
110.	*	Format of data recording	alphanumeric string**
111.	*	Number of colors or gray levels used	integer
112.	*	Distribution of colors or gray levels	alphanumeric string

Examination Results

113.	*	Scan segment number	integer**
114.	*	Scan segment description	alphanumeric string
115.		Scan segment location on part	alphanumeric string
116.		Scan segment orientation	alphanumeric string
117.	*	Scan pattern description	alphanumeric string
118.		Annotation	alphanumeric string**
119.	*	Distance between data sample points	real number
120.	*	Interval between data locations in index direction	real number
121.		Notes on data intervals	alphanumeric string
122.		Notes on data format including notes on any compression techniques used	alphanumeric string
123.	*	Total number of data points	integer**
124.	*	Actual stream of ultrasonic data	real numbers**

6. Explanation of Fields

1.	Intermediate file name	The name of the data base file containing all of the information to follow. This is the transfer or archive file itself.
3.	Format revision date	The date of the file format code used for the data base file being created. Enter in the form of four digits for the year, two digits for the month, and two digits for the day of the month.
6.	Examining company and location	The legal name and location of the company which performed the ultrasonic examination.
9.	Type of examination	For example, one of the following may be used: Through-Transmission Pulse-Echo Amplitude Pulse-Echo Time-of-Flight Reflector Plate Full Digitized Waveform Multivalued Data etc.
10.	Other examinations performed	Identify other nondestructive examinations performed on this part, such as: X-Radiography (film based) X-Radioscopy (Video tape record) Infrared Thermal Examination etc.

16.	System of Units	Specify whether SI (cm) or English (inch) units are used for specifying dimensional quantities.
18.	Examination system manufacturer(s)	Give the name of the ultrasonic system manufacturer. Where multiple vendors are involved, give the name of the manufacturer for each subsystem. Also give the Model name and number and serial number of each subsystem for the following fields.
23.	Pulser type	For example: Spike Pulse, Square Wave, Tone Burst, etc.
25.	Pulse height	Indicate the amplitude of the electrical pulse in volts and identify whether the measurement is peak-to-peak, rectified, etc.
31-32.	Receiver frequency and bandwidth	Give the manufacturers specified nominal values.
38.	Gate type	For Example: Flaw Gate, Back Echo Gate, Transmission Amplitude Gate, etc.
49.	Location of beam dia. meas.	For immersion examinations measure per E 1065 For squirter examinations measure through the water stream at the working distance For contact tests use the active element diameter
50.	Search unit focal length	Enter the focal length of the search unit. For flat search units, enter a value of 0.0
56-58	Transmit search unit waveform	Provides a digitized waveform of the search unit recorded from the reflection from a flat plate. Waveform should be representative of the manner in which the search unit is used in the system. Include a description of the manner in which the waveform was digitized.
65.	Location of beam dia. meas.	See notes for item 49.
66.	Search unit focal length	See notes for item 50.
72-74	Receive search unit waveform	See notes for items 56-58.
80.	Examined sample notes (history, use, etc.)	Give any service data available for the article including service use hours, aircraft or system assignments, and special incidents, such as collisions, impacts, hail storms, fires, etc.
85.	Reference sample notes	Describe how the sample was used in the setup of the ultrasonic system response; reject response level, etc.
86-89	Machine Coordinate System	Describe the coordinate system used by the original inspection equipment. Reference to the receive search unit. For example, scan axis = X-axis, positive right; index axis = Y axis, positive down; Z-axis, positive away.

90-93 Part Coordinate System	Describe the coordinate system of the part in the scan frame. Give the origin and unit vectors as referenced to the machine coordinate system.
102. No. of data values per coordinate	Where multivalued scans or digitized waveforms are included, indicate the number of values recorded at each point and the significance of each. The definitions of fields 103 through 112 may need to be repeated for each of the multivalued parameters.
103. Min value of the examination data range	The lower bound of the pixel value for the data type. For example, 00.
104. Max value of the examination data range	The upper bound of the pixel value for the data type. For example, 127 or 255.
105. Engineering units for min legal value	Give the significance of the value in item 100. For example, 00 represents saturation of the A/D which occurs at 5.0 volts at the input to the preamp. It is important that the units for fields 105 and 106 be the same (dB, volts, etc.)
106. Engineering units for max legal value	Give the significance of the value in item 101. For example, 127 represents a signal strength 127 dB below the saturation level, or 2.2 microvolts at the input to the preamp. (In practice the noise floor typically occurs at approximately 50 microvolts which would give a pixel value of 100.)
108. Type of data scale	For example, linear, logarithmic, etc.
109. Size of data step	For example, 1.0 (dB), or 0.0025 (inch thickness).
110. Format of data recording	For example, ASCII, numeric values ASCII, characters binary, two 8-bit words etc.
113. Scan segment number	Enter the sequence number for this segment of the scan data. If the entire part is scanned in one pattern and all of this data is saved in a single file, there will be only one scan segment for the part (and perhaps one for the reference standard).
118. Annotation	Report any annotation included with the file. Annotations should be referenced to part coordinates.
123. Total number of data points	Number of pixels in image. May be given in terms of rows and columns, for example 256 x 256.
124. Actual stream of ultrasonic data	The actual stream of data conforming to the limits, significance and format given above.

7. Key Words

Database
Data Transfer
Data Storage
Data Retrieval
Guide
Nondestructive Testing
Ultrasonic Examination
Ultrasonic Image

APPENDIX B

REPORT ON THE WORKSHOP
ON THE EXCHANGE OF DIGITAL ULTRSONIC DATA,
HELD AT NIST, GAITHERSBURG, MD,
NOVEMBER 7 AND 8, 1989

INDUSTRIAL
QUALITY
INC 19634 CLUB HOUSE ROAD, SUITE 320 P.O. Box 2519 GAITHERSBURG, MD 20879
Telephone 301-948-2460, 301-948-0332, FAX 301-948-9037

November 10, 1989

Department of the Navy
Naval Air Systems Command
Attn: AIR 931A
Washington, DC 20361

Subject: Quarterly Progress Report, Contract No. N00019-89-C-0275, "Development of Data File Standards and Data Exchange Protocols for Automated Ultrasonic Scanning Systems".

Gentlemen:

During this initial period of the contract, we have established communication and discussed plans with the three subcontract organizations and planned and conducted a Workshop on the Exchange of Digital Ultrasonic Data. The Workshop provided an opportunity to discuss program directions with many knowledgeable people and confirmed our ideas about performing the ultrasonic data exchange within a recognized exchange specification, such as the Initial Graphics Exchange Specification (IGES) or the Product Data Exchange Specification (PDES). The Workshop also provided guidance in selecting terms (or fields) and definitions for important parameters of the ultrasonic data file. In addition, the Workshop permitted a good exchange of information among the contractors and the NADEP personnel who will be involved in the contract demonstration data exchange.

The major topics reviewed at the Workshop included details of the three ultrasonic systems to be involved in the demonstration exchange, the parameters of the ultrasonic system and data that must be included and defined, and the advantages and limitations of the possible useful exchange systems. The final agenda for the Workshop is shown as Figure 1. An attendee list is given in Figure 2. The exchange demonstration plan is described in Figure 3.

The attendees included representatives from NAVAIR, Navy personnel concerned with ultrasonic inspection, key personnel from the National Institute of Standards and Technology (NIST) and the contract team. Representatives from the NADEPs at Cherry Point and North Island participated in the discussions, providing information about their

ultrasonic systems and their ideas concerning data exchange. The two representatives from Norfolk attended to provide inputs concerning their (and the Navy's) extensive use of portable, computer-based ultrasonic scanning systems such as the SAIC Ultra-Image. The broad, practical inspection experience of Gwynn McConnell, NADC, was extremely useful, as were the ultrasonic and data transfer comments provided by Henry Chaskelis, NRL. The NIST personnel included Don Eitzen, an ultrasonic specialist and three staff persons, Reed, Rumble and Smith, much involved in data exchange standards. Their inputs throughout the workshop were very valuable.

The present list and definitions of the ultrasonic fields are presented in the multi-page Figure 4. This list was appreciably expanded and clarified during the Workshop. This field listing will be a topic for further work in the coming quarter as we complete the gate section, decide on those parameters that are necessary for an understanding of the exchanged data and begin to put the field list in an appropriate machine language.

The exchange specifications were discussed at length, taking advantage of the presence of several NIST data exchange people. The consensus was that no existing data exchange specification contains all the capabilities needed for the ultrasonic data problem. However, there are elements in several exchange specifications that appear to be useful. These include elements such as product description, location parameters, etc. We plan to examine several specifications in more detail to determine what portions may be applicable to the ultrasonic exchange issue. The review will include IGES, the draft version of PDES, the Dimensional Measurement Interface Specification (DMIS), the medical ACR-NEMA standard on digital imaging and communication, and several graphics standards.

We remain interested in PDES because of its planned use for manufacturing and life cycle applications. The modeling language used in PDES is Express. As an interim step, we plan to put our field structure in Express language. This will provide several advantages. Near-term advantages include verification of the completeness of the field structure and assistance in the design of translators. A long term advantage is the compatibility with PDES.

Plans for the coming quarter include further work with the field terms, definitions and language and reviews of existing exchange specifications to determine useful sections.

Sincerely yours,

H. Berger

Harold Berger, P.E.
President

Distribution:

Naval Air Systems Command

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AIR 5304	1 copy
AIR 21513B	1 copy

Enc.

HB/db

FIGURE 1. Workshop agenda

WORKSHOP ON EXCHANGE OF DIGITAL ULTRASONIC DATA

November 7 and 8, 1989

Organized by Industrial Quality, Inc.
as part of
Naval Air Systems Command
Contract No. N00019-89-C-0275

Location: National Institute of Standards and Technology
Sound Building, Room A109
Gaithersburg, MD

Tentative Agenda

Tuesday Nov. 7, 1989

9:00 Welcome

9:10 Introduction to the Data Exchange Program - Harry Berger

9:40 Description of MCAIR Ultrasonic System - Steve Terneus

10:10 Break

10:25 Description of Cal Data Ultrasonic System at North Island - Dave White

10:50 Description of Sigma Ultrasonic System at Cherrrry Point - Tim Harrington

11:15 Description of Data Exchange Specifications IGES and PDES - Brad Smith

12:00 Description of Dimensional Measurement Interface Specification - Tony Cheng

12:30 - 1:30 Lunch

1:30 - 5:00 *Discussion of Proposed Fields Included in Data Exchange
*Glossary of Terms

Wednesday November 8, 1989

9:00 -12:00 *Discussion of Exchange Specifications
* Need for Hardware and Software

12:00 - 12:30Summary

12:30 - 1:30 Lunch

1:30 - 5:00 Open for further discussion

FIGURE 2. Workshop attendees

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FIGURE 2. Continued

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FIGURE 3

PLANNED ULTRASONIC DATA EXCHANGE

* THREE WAY EXCHANGE OF ULTRASONIC DATA INVOLVING A NAVAL AIRCRAFT MANUFACTURER (MCAIR) AND TWO NADEPS (NORTH ISLAND AND CHERRY POINT)

MCAIR: St. Louis, MO	Automated Ultrasonic Scanning System, AUSS - IV, as used in production
NORTH ISLAND: San Diego, CA	Automation Industries scanner modified with Cal Data data package Multisonic PC Instrumentation and Data Aquisition and Imaging (3)
CHERRY POINT: Cherry Point, NC	Sigma ultrasonic squirter scanning system, Model 2000

FIGURE 4. ***Ultrasonic Data File Proposed Field Name Descriptions*** (5 pages)

Header Information

Testing Company
The legal name of the company which performed the ultrasonic examination.

File Name
Name of the intermediate format file.

Format Revision
Revision Letter (Number) and Date of the Exchange Format to which this file conforms.

Source File Name
File name (and path) of the source file(s) from which the data was translated.

Test File Description
Enter a description of the nature of the data file including the reason for and timing of the test.

Test Date/Time
Enter the date and time at which the scan was initiated.

Type of Test
e.g., Ultrasonics, Radioscopy, Infrared.

Other Tests Performed, or Results Availability
For Example, X-Radiography (Film based), X-Radioscopy (Video Tape Record), Infrared Thermal Inspection.

Operator I.D.
Name and Employee Number or other identification of the inspector.

Inspection Specification
The specification and/or procedure to which the inspection was performed, including revision letter and date.

Acceptance Criteria
Enter the criteria to which the component was evaluated. May be by reference to specification and class.

Notes
Enter any additional information which describes the nature or purpose of the inspection.

Inspection System Description

System Manufacturer
Give the name of the Ultrasonic System manufacturer. Where multiple vendors are involved, give the name of the manufacturer of each subsystem.

System Model/Serial Number
Give the Model Name and Number and the serial number of the system identified above.

Specific Test Method
e.g., Thru-Trans, P-E Amplitude, P-E Time of Flight, Reflector Plate, Full Digitized Waveform, Multivalued Data.

Pulser Section

Make and Model of Pulser Electronics
(e.g. Automation Industries PR-2).

Pulser Type/Shape
e.g., Spike pulse, 1200 volts; Square wave, 300 volts, 100 nsec width; Tone Burst, 50 volts, 5 Mhz, 5 cycles.

Last Calibration Date
Enter the date the pulser module was last calibrated.

Notes on Pulser Section
Enter any additional information about the pulser system.

Receiver Section

Receiver Electronics Make and Model
Similar to Pulser, in fact may be same unit as pulser.

Receiver Electronics Response Center Frequency
e.g., 1.0 MHz, 2.25 MHz, 5.0 MHz, 10.0 MHz, Broad Band .

Receiver Gain
Enter the gain setting used in the receiver electronics. Include any fixed as well as user selectable gain. (Describe time variable gain in the notes section.)

Last Calibration Date
Enter the date the pulser module was last calibrated.

Notes on Receiver Section
Provide any additional information on the receiver section including the nature of any time variable gain which is in use.

Gate Section

Entries to be determined

Transducer Section

Transmit Transducer Make and Model
Give the name of the manufacturer of the transducer and the manufacturer's designation of the model of transducer, e.g., Aerotech Alpha

Transmit Transducer Serial Number
Give the manufacturers serial number for the specific unit used.

Transmit Transducer Element Diameter
Enter the diameter of the active element in inches.

Transmit Transducer Beam Diameter
Enter the effective beam diameter (in inches) of the transducer at the inspection surface. For immersion tests, give the beam diameter as measured in ASTM E1065. For squirter tests, give the effective beam diameter measured through the water stream at the working distance. For contact tests, enter the active element diameter.

Transmit Transducer Focal Length
Flat = 1, Long Focus (focal length more than 10 element diameters) = 2, Medium Focus (focal length 5 to 10 element diameters) = 3, Short Focus (focal length less than 5 element diameters) = 4.

Transmit Transducer Response Center Frequency
Report the center frequency for this transducer as measured in accordance with ASTM E1065.

Transmit Transducer Response Bandwidth
Report the bandwidth for this transducer as measured in accordance with ASTM E1065.

Ultrasonic Data File Proposed Field Name Descriptions

Transmit Transducer Digitized Waveform

Provide a digitized waveform of the transducer recorded from the reflection from a flat plate. Waveform should be representative of the manner in which the transducer is used in the system. Include a description of the manner which the waveform was digitized.

Transmit Transducer Coupling Technique and Medium

For example, Water squirter, 0.25 inch diameter stream, aged and filtered water with wetting agent and corrosion inhibitors.

Receive Transducer Make and Model

Give the name of the manufacturer of the transducer and the manufacturer's designation of the model of transducer, e.g., Aerotech Alpha

Receive Transducer Serial Number

Give the manufacturers serial number for the specific unit used.

Receive Transducer Element Diameter

Enter the diameter of the active element in inches.

Receive Transducer Beam Diameter

Enter the effective beam diameter (in inches) of the transducer at the inspection surface. For immersion tests, give the beam diameter as measured in ASTM E1065. For squirter tests, give the effective beam diameter measured through the water stream at the working distance. For contact tests, enter the active element diameter.

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Report the center frequency for this transducer as measured in accordance with ASTM E1065.

Receive Transducer Response Bandwidth

Report the bandwidth for this transducer as measured in accordance with ASTM E1065.

Receive Transducer Digitized Waveform

Provide a digitized waveform of the transducer recorded from the reflection from a flat plate. Waveform should be representative of the manner in which the transducer is used in the system. Include a description of the manner which the waveform was digitized.

Receive Transducer Coupling Technique and Medium

For example, Water squirter, 0.25 inch diameter stream, aged and filtered water with wetting agent and corrosion inhibitors.

Test Sample Description

Test Sample I.D.

For example, the part number and serial number or log number.

Test Sample Name/Description

Give the Part Name and any other identifying information.

Test Sample Material

For example, Graphite Epoxy Skins on Aluminum Honeycomb Core.

Notes (History, Use, etc.)

Enter any service data available for the article including flight hours, aircraft assignments, and special incidents, such as impacts, collisions, hail storms, fires, etc.

Ultrasonic Data File Proposed Field Name Descriptions

Number of Scan Segments for This Part

If the scan of the part is accomplished in multiple physical segments, enter this information.

Reference Standard I.D.

Give the name or number of the reference standard used.

Reference Standard Description

Describe the materials and sizes, types and locations of any reference or incidental discontinuities.

Reference Standard File Location

Give the name and location of the intermediate format file containing the ultrasonic data for the reference standard used for the inspection of this part.

Coordinate System and Scan Description

Machine Coordinate System

Describe the coordinate system used by the original inspection equipment. Reference to the receiver. For example, scan axis = X axis, Positive right; index axis = Y axis, positive down; Z-axis, positive away.

Part Coordinate System

Describe the coordinate system of the part in the scan frame. Give the origin and unit vectors as referenced to the machine coordinate system.

Object Target Points

Enter the number of target points used, their coordinates, and descriptions of their locations on the part.

Data Plane

Describe (in words) the plane onto which the data will be projected.

Coordinate System Notes

Provide any additional information which would help to clarify the coordinate system and/or part orientation.

Number of Data Points per Coordinate Location

Where multivalued or digitized waveforms are included, indicate the number of values recorded at each point and the significance of each. the following data definitions may need to be repeated for each of the multivalued parameters.

Test Data Legal Range/Resolution

Min Legal Value: Max Legal Value.

Engineering Units for Minimum Legal Data Value

e.g., 0.00 inch part thickness

Engineering Units for Maximum Legal Data Value

e.g., 0.612 inch part thickness

Data Sample Resolution

Give the number of bits to which the original data was digitized.

Data Scale

e.g., Linear

Data Step Value

e.g., 0.0024 inch per step

Ultrasonic Data File Proposed Field Name Descriptions

Data Type

Give the format of the data as it is recorded in the intermediate format file; e.g., ASCII, numeric values; or Binary, 16 bit in two 8-bit words.

Data Interpretation Settings

Describe the number of colors and or gray levels used in the interpretation, and the distribution of the data values over those colors or gray levels, e.g., 64 gray level graphics systems, gray levels distributed uniformly over the range 16 dB (white) to 48 dB (black).

Test Data

Scan Segment Number

Enter the sequence number for this segment of the scan data. If the entire part is scanned in one pattern and all of this data is saved in a single file, there will be only one scan segment for the part (and perhaps one for the reference standard).

Scan Segment Description

Describe the contents of this scan segment.

Scan Segment Location and Orientation

Give the location and orientation of the segment on the part. Include the bounds on the scan area described by bounding points, lines, and/or planes.

Scan Pattern Description

Describe the scanning pattern. For example, raster scan, scan lines in pure X extending to bounding lines.

Annotation

Report any annotation included with the file. Annotations should be referenced to part coordinates.

Data Sample and Index Axis Interval (Including Units)

Enter the distance between data sample points followed by the interval between data locations in the index direction. For example, 0.040 inch; 0.040 inch.

Notes on Data Intervals

For example, consecutive scan lines are spaced in 0.08 inch intervals; consecutive real scan lines are averaged to synthesize intervening scan lines, thus producing 0.040 data file index interval.

Total Number of Data Points

Input total number of data points for this scan segment.

Data Stream

The actual stream of ultrasonic data conforming to the limits, significance and format given above.

APPENDIX C

REPORT ON DEMONSTRATION
OF DIGITAL ULTRASONIC DATA EXCHANGE
HELD AT IQI, GAITHERSBURG, MD
JUNE 5, 1991

DEMONSTRATION OF DIGITAL ULTRASONIC DATA EXCHANGE

A demonstration of data exchange capability was held at the offices of Industrial Quality, Inc., Gaithersburg, MD for NAVAIR and other government personnel on June 5, 1991. Attendees present represented NAVAIR, NADEPs at Cherry Point, Jacksonville and Norfolk, the Naval Air Development Center and the National Institute of Standards and Technology; see attendance list.

The demonstration started with a brief review of the program, the objectives and the approach. Hard copy data exchange results were shown, including data originating at MCAIR, North Island and Cherry Point showing reproduced data at MCAIR, North Island and IQI. The exchange files reproduced on the IQI 486 PC during the demonstration were those shown in the body of this report, Figures 3, 4 and 5.

An initial draft report for the 2-year data exchange program was distributed during the demonstration meeting. Attendees were favorably impressed with the data exchange capability demonstrated during the meeting. Attendees were encouraged to share ideas with the IQI staff as we firm up the draft final report for submission to NAVAIR during the month of June, 1991.

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